Investigations into the Elemental Composition of Earthenware Vessels from the Guthe Collection using Instrumental Neutron Activation Analysis

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INTRODUCTION: LOCAL EARTHENWARE VESSELS OF THE CENTRAL VISAYANS

IMPORTANT TO THE GROWTH of chiefdom polities in the Philippines is the expansion of internal trade between coastal and inland groups (Bacus 1990 : 349–350; Junker 1999 : 262). Ethnohistorical and archaeological evidence indicate that earthenware pottery manufactured by lowland coastal potters was one of the primary products traditionally exchanged between coastal and inland groups. While the increasing value placed on import ceramics (porcelain and celadon) and their role in the political economy has been well documented, local dimensions of production and internal trade are also important to an understanding of the political economy. Specifically, the organization of local pottery production may have changed to accommodate the development and consolidation of alliances between coastal and interior groups, as Junker (1999) discovered in the Tanjay chiefdom (264). During the height of Tanjay's power, which spanned the early to mid second millennium AD, growing status stratification between elites spurred an expansion in regional earthenware exchange (Junker 1999 : 290–291). Earthenware were not only functional domestic vessels but also facilitated feasts and public gatherings held by chiefs. Control over the manufacture and distribution of these wares was thus economically important to the creation of political alliances and subjects.

The identification of compositional groups within local earthenware assemblages presents a potential means to the evaluation of exchange and production systems. Junker's (1990) study of temper and morphology of earthenware represented a seminal approach to the detection of local versus non-local ware. More recently, Niziolek (2013) used laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) to identify differences in clay composition in the Bais-Tanjay region of Negros Island. Her analysis indicate that earthenware production was organized as both as a non-specialized and full-time centralized craft in the Tanjay polity. In this article, I undertake a preliminary investigation of earthenware production and distribution by conducting instrumental neutron activation analysis (INAA) on earthenware samples

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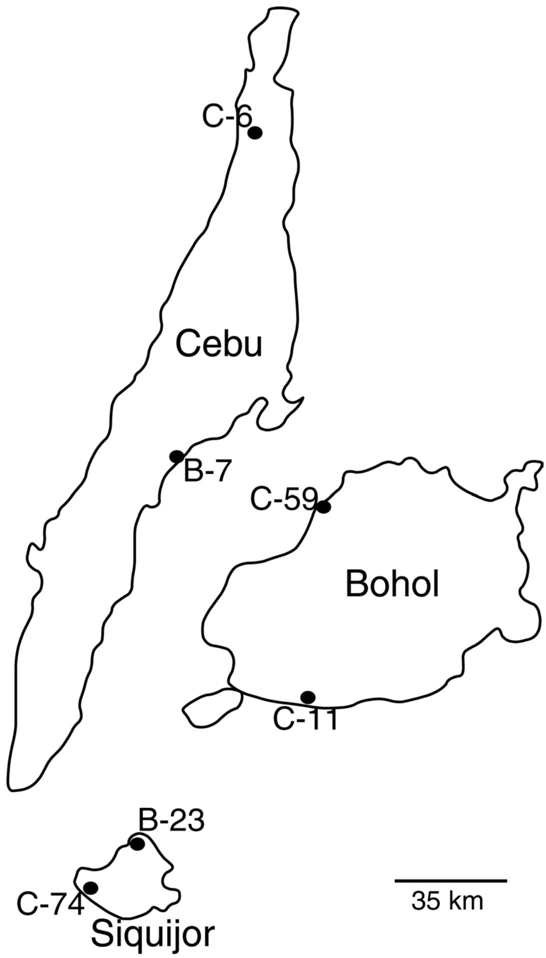

Fig. 1. Map of the study area and approximate site locations (after Guthe 1929).

that Guthe collected from adjacent island polities considered to be contemporaneous with Tanjay. The detection of compositional patterns in the earthenware assemblage from the Visayan region may help identify distinct production groups. It must be acknowledged that a pilot study of this kind may not achieve sufficient resolution to identify elemental groupings, but anticipates the chemical profiles generated will serve as a valuable reference material for future studies in this part of the world.

GEOGRAPHICAL AND GEOLOGICAL BACKGROUND

The islands of Cebu, Bohol, and Siquijor, located in the Visayan region, serve as the area of study (Fig. 1). Accounts of craft production exist for the Cebu chiefdom, but mainly refer to full-time specialization in iron, metal goods, and textile production, and not in utilitarian items such as earthenware (Junker 1999 : 267). In addition to the tradeware, Guthe also collected samples of whole and incomplete earthenware vessels.

A critical initial step in the evaluation of clay composition is an understanding of the regional geologic history to determine the possible elemental representation in the raw material. The earliest deposits on Cebu, Bohol, and Siquijor date from the Palaeocene-Eocene period (Philippine Geological Survey Division 1963). Geologic description for the region is most comprehensive for Cebu, which often serves as a generalization for the Visayan region (Smith 1924 : 195). A comparison of the geologic formation for the region suggests the interior of the islands consists of a fairly consistent distribution with igneous and volcanic rocks, largely from the Palaeocene-Eocene period. From the intermediary uplands to the coastal areas, more recent formations of sedimentary and metamorphic material are typical.

According to Smith's (1924) description, the central cordillera (interior mountains) of Cebu are comprised mainly of igneous and metamorphic material where diorite is the basal complex rock (99). The chief characteristic of the diorites is the considerable amount of hornblende and feldspar with a predominance of plagioclase (98). True granite is a rare rock in the Philippines; Smith (1924) suggests that the "granites" in the cordillera region conform more closely to the composition of grano-diorite type (102). The remainder of the island extending from the *mesetas* or "little table lands" (between the cordillera and intermediate uplands) to the coast is characterized by limestone, sandstone, arkose, and tuffic material (191). Unfortunately, the precise mineral contents of these clastic formations are of a fragmentary nature for the island. Smith's petrographic analysis of one Cebu arkose specimen shows a composition rich in feldspar mineral (orthoclase) and little biotite and olivine, suggesting weathering from interior dioritic materials. The coastal plains are also covered with alluvial deposits.

SAMPLE SELECTION

Because this pilot project allowed for 24 samples to be submitted for INAA, only a limited number of potsherds from each island could be tested. Attempt was made to

Table 1. Relative Site Dates and Locations

SITE	SAMPLE SIZE	DATE	DIAGNOSTIC POTSHERD
C59 Barrio Ta-oran Inabanga, Bohol	1	Unknown	
C11 Sucgan Cave Loay, Bohol	8	13th–15th centuries A.D.	Chinese celadon, porcelain, and dragon jar
B7 Barrio Naga Cebu, Cebu	3	mid-14th–16th centuries A.D.	Chinese celadon and porcelain
C6 Calavera, Cebu	4	13th–15th centuries A.D.	Dragon jars
B23 Barrio Sulangon San Juan, Siquijor	7	11th–(?) century A.D.	White stoneware and iron
C74 Barrio Maite San Juan, Siquijor	1	11th (?)–15th centuries A.D.	Iron knife and porcelain*

Notes: Guthe based site locations on the nearest *barrio* (district) in each municipality. Bacus (1995 : 185–200) provided a detailed summary of Guthe's descriptions of the physical surroundings and archaeological finds associated with individual sites.

select an equal number of sites and number of samples from each of the adjoining islands of Bohol, Cebu, and Siquijor (Table 1). The sample intended to capture compositional variability of a known type within a defined spatio-temporal context. With the exception of complete earthenware vessels, the selection process screened potsherds based on two criteria: datable contexts and diagnostic vessel forms. Chronological dates were determined for each site based on relative cross-dating with the presence of tradeware and iron implements (Table 1).[1] The sample is represented by two sites from each island and seven to nine potsherds from each site, with the exception of sites C-59 and C-74, which each only produced one due to the limited availability of diagnostic potsherds.

Following the morphological typology developed by Junker (1990) and Bacus (1995) for prehistoric earthenware and Guthe's annotated notes on the individual artifacts, samples were classified as globular shaped pots for cooking, shallow bowl-shaped vessels, or restricted jar-like vessels (Bacus 1995 : 263). Most of the utilitarian earthenware in this sample are of the globular cooking pot type, given their greater occurrence as grave goods in the mortuary context. Shallow bowl-shaped vessel and jar-like vessel types were also included in the study to account for further possible variation. Table 2 is a detailed listing of the samples. Illustrations of the samples are shown in Figures 2 through 4.

The small sample size and the wide range of variation in site location certainly raise concerns about achieving the elemental resolution necessary to detect grouping. However, given the sample limit of this project and the preliminary nature of the investigation where no elemental library was available for the region, I chose to follow this selection criterion.

METHODS

The use of INAA in elemental analysis of archaeological materials has emerged as a significant technique because of its great sensitivity and resolution, especially in comparison with other available techniques. Given the geologic and cultural variability of clay composition encountered in this study, the large suite of elements and concentration levels (ppb) analyzable by INAA make it a particularly appropriate application. Specifically, slight differences in elemental composition and/or concentration levels can have important implications about provenance. For a thorough discussion on the principles of activation analysis, see Kruger (1971) and Muecke (1980).

Contaminants were cleaned off the surface of each potsherd with a carbide bit and sherds were washed with distilled water. Then, the sample was pulverized with a mortar and pestle and subsequently dried in an oven for 48 hours. One hundred fifty mg of the sample was then measured out with an allowable difference of 10 mg and encapsulated in high-quality quartz tubes. One hundred fifty mg of standards (NIST 1633 A; N = 3) and check standards (NIST 1633b Ohio Red Clay; N = 2) were weighed out. In addition, one blank was included. Irradiation was undertaken in the Ford Nuclear Reactor (FNR) and two counts were taken (Batch #R935-01-1Q), the initial at 5 weeks and the second at 10 weeks.

The elements analyzed include predominantly the most precise on both reference materials with coefficients of variation typically less than 5 percent. Remaining elements that were less precise on one or both standards were also included. FNR values were further corroborated against University of Missouri–Columbia Research

TABLE 2. SAMPLE LIST AND DESCRIPTION

SAMPLE #	ARTIFACT #	ISLAND	CATALOG #	DESCRIPTION
AY1	C-11-382	Bohol	48992	Everted rim of possible globular vessel with cord impression
AY2	C-11-382	Bohol	48739	Body potsherd of possible globular vessel
AY3	C-11-382	Bohol	48994	Everted rim globular vessel
AY4	C-11-382	Bohol	48741	Body potsherd from globular vessel
AY5	C-59-3	Bohol		Inverted rim from a restricted vessel
AY6	C-11-383	Bohol	48977	Everted rim with neck of globular vessel
AY7	C-11-383	Bohol	48978	Everted rim of globular vessel
AY8	C-11-383	Bohol	48970	Everted rim of globular vessel
AY9	B-7-21b	Cebu		Everted rim and body of globular vessel
AY10	B-7-19	Cebu		Inverted rim of unrestricted vessel "shallow bowl"
AY11	B-7-21a	Cebu		Everted rim of globular vessel
AY12	C-6-a	Cebu		Inverted rim from vessel of simple restricted shape
AY13	C-6-d	Cebu		Everted "lipped" rim of restricted vessel
AY14	C-6-b	Cebu		Everted "lipped" rim of restricted vessel
AY15	C-6-c	Cebu		Everted "lipped" rim with neck of restricted vessel
AY16	C-11-383	Bohol	48971	Everted rim with neck of globular vessel
AY17	B-23-10e	Siquijor	48675	Everted rim from globular vessel
AY18	B-23-10d	Siquijor	48675	Body potsherd of globular vessel
AY19	B-23-10c	Siquijor	48675	Everted rim from restricted vessel
AY20	B-23-10b	Siquijor	48675	Base fragment from jar vessel

Note: Some artifacts have catalog numbers while others have field numbers, following the cataloging conventions used in the collection.

Reactor Center (MURR) values to verify for accuracy. Table 3 shows the elements analyzed in this study and the elemental output for individual samples is provided in Appendix 1.

The decision of which elements to analyze, as discussed above, was largely dependent on the precision of the detection values. Elements that have decayed beyond detection limits were further excluded because of the missing values. For elements where there was more than one energy line (*Ba*), cross-checking and evaluation against the reactor's log for the two energy lines determined the accuracy of the line. Further concern over which elements to use stemmed from negative detection counts, probably due to the extent of elemental decay. In these instances (*Rb*, *Sr*, *Ta*, *Tb*, *Cs*,

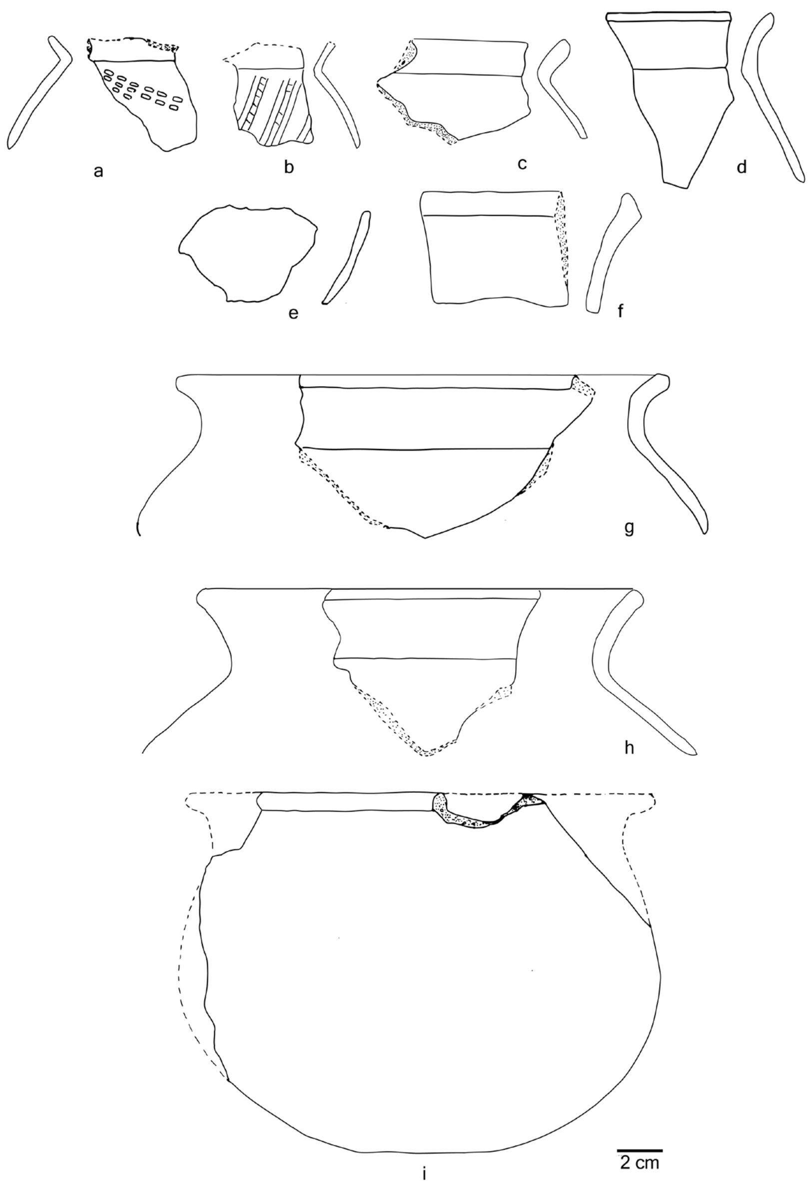

Fig. 2. Earthenware potsherds from the island of Bohol. Clockwise from left—a: AY03; b: AY01; c: AY05; d: AY07; e: AY02; f: AY05; g: AY16; h: AY08; and i: AY04.

Sb, *K*), where the difference between the negative value and the smallest positive value was close, I changed the negative value to a positive one. However, for those elements in which the difference between the negative and smallest positive value was great, I excluded the element from analysis (*Sr*).

Certain elements were of greater interest to this study given the geologic information known about the specific areas. In particular, in the alkali group, elements such as *Na*, *K*, *Ba*, and *Rb*, which are associated with feldspar minerals, could yield

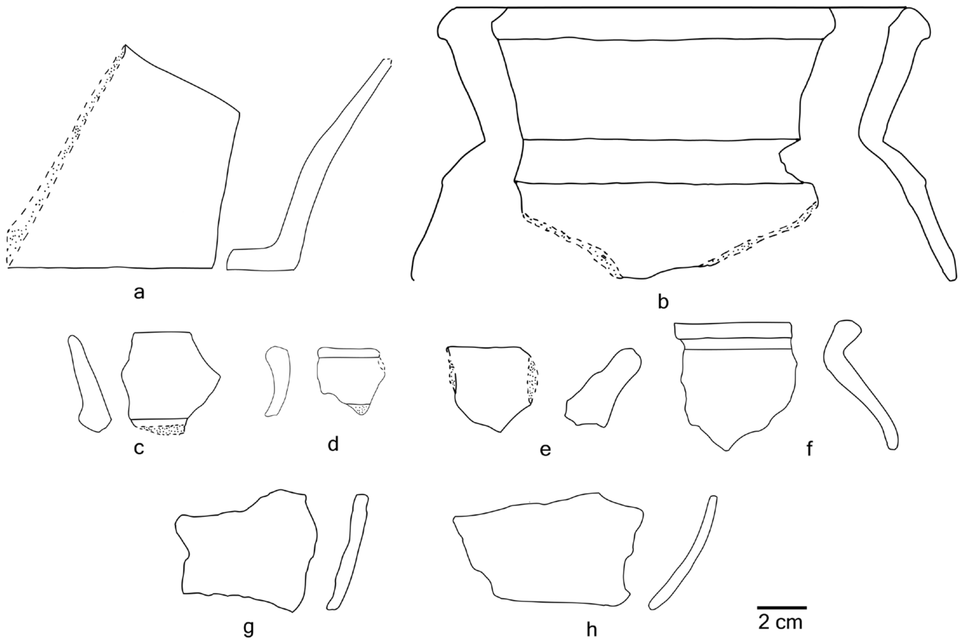

Fig. 3. Earthenware potsherds from the island of Siquijor. Clockwise from left—a: AY24; b: AY21; c: AY20; d: AY17; e: AY19; f: AY22; g: AY23; and h: AY18.

differential concentrations that may be significant at identifying compositional groups. The first transition metal *Sc* is equally critical to this study because differential concentrations may similarly identify distinctive clay sources and offer a description of production groups.

RESULTS

Preliminary bivariate plots for alkali elements and transition metals show no clear separation between the sites, presenting a distribution pattern that was rather interdispersed (see Figure 5). Instead of focusing on separation at the site level, the following bivariate analysis attempted to look for differentiation in the overall assemblage since our sample size for each site may have been too small to provide sufficient resolution. Preliminary group separations observed in bivariate plots were subsequently examined in multivariate space using cluster analysis. I chose to use hierarchical clustering and the Ward linking algorithm for the cluster analysis, a method that evaluates the homogeneity of clusters by minimizing the total sum of squared deviations from the mean (the error sum of squares or ESS) (Shennan 1997). If sufficient distance measures showing dissimilarity could be determined in the dendrogram, then I accepted the preliminary groupings and coded the groups. Confidence interval ellipses (set at 95% level) were then fitted to confirm group membership. If the ellipses for each group did not overlap, then I interpreted this as confirmation of the individual observation's membership in the group, or 95 percent probability of where the distribution is expected to lie.

Group separation is strongest for two elements in the alkali group: Na and Ba496. Bivariate analysis for other suites of did not produce clear and consistent patterns

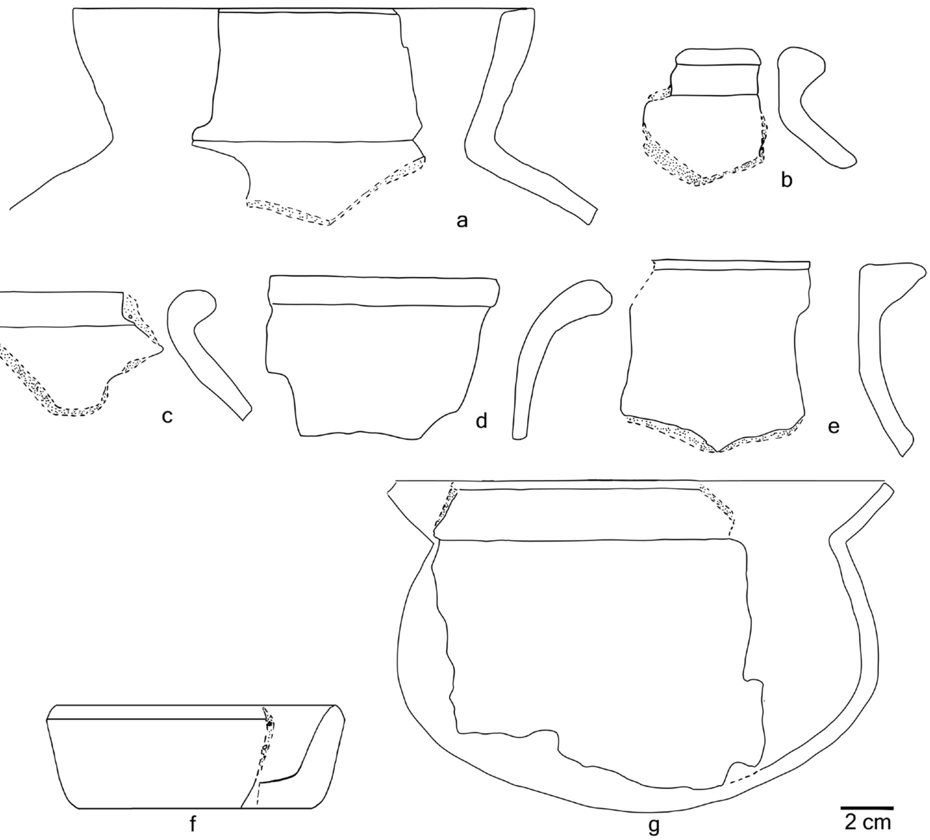

Fig. 4. Earthenware potsherds from the island of Cebu. Clockwise from left—a: AY11; b: AY15; c: AY13; d: AY14; e: AY12; f: AY10; and g: AY09.

Table 3. Elemental Groups Analyzed in the Study

Alkali group	**Rb** (<5%)	**Cs** (<5%)	**K**	**Na**	**Ba496**			
Transition	**Sc** (<5%)		**Hf** (<5%)	**Cr** (<5%)	**Fe** (<5%)	**Co** (<5%)	**Zn**	
Other metals and nonmetals	**Sb**	**Th** (<5%)						
	As							
Rare earth elements	**Ce** (<5%)	**Sm** (<5%)	**Eu** (<5%)	**Tb**	**Yb** (<5%)	**Lu** (<5%)	**La** (<5%)	**U228**

(see Figure 5). Figure 6 shows the bivariate plot, cluster dendrogram, and distance measures of the three groups, labeled A, B, and C in Figure 6. The confidence ellipse at 95 percent level grouped by each cluster further confirms the membership of these observations in the individual groups: the ellipses for each cluster do not overlap. Group A (N = 4) is characterized by low concentrations of Na and Ba496. Impressionistic observations suggest that group B (N = 11) is characterized by

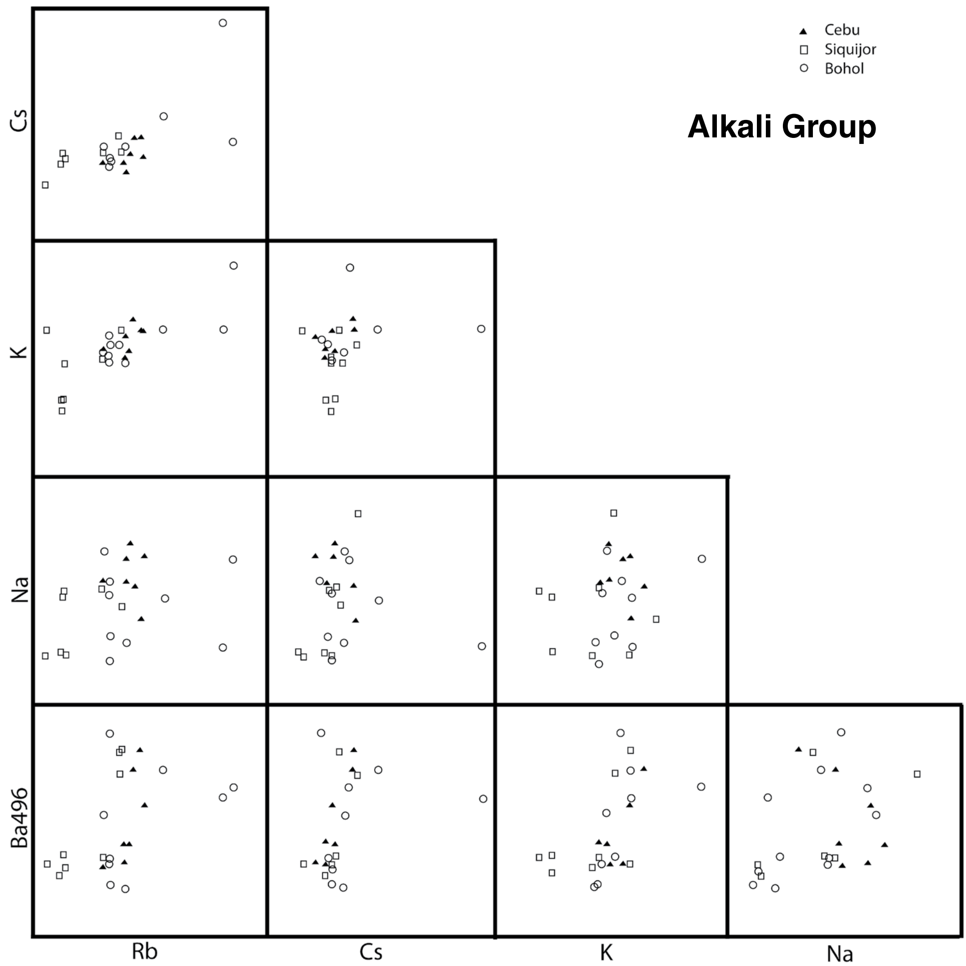

Fig. 5. Bivariate plots of A) alkali; B) transition metal; and C) rare earth elemental groups.

greater concentrations of Na and group C (N = 5) by greater concentrations of Ba496.

Another point meriting further consideration is within-group variation. Though CI intervals appear to enclose and separate cases into distinct groups (Figure 6), within-group variation was not consistent for the three groups. Within-group variation was relatively tight for group A and C but very loose for group B. This is due to the larger set of observations grouped into B in contrast to the four observations comprising A and C due to the cluster solution. Group B cluster solution may have been influenced significantly by the wide variation in the concentration of Ba496.

Further exploration of bivariate distributions did not show other elemental differentiation except for As. As appeared to be the only other element distinctive to Group A. Figure 7 shows Group A separation for As and Na and a 95 percent CI around the three clusters. The bivariate distribution for As indicates a greater tendency toward higher concentrations of As in Group A in contrast to the rest of the data set.

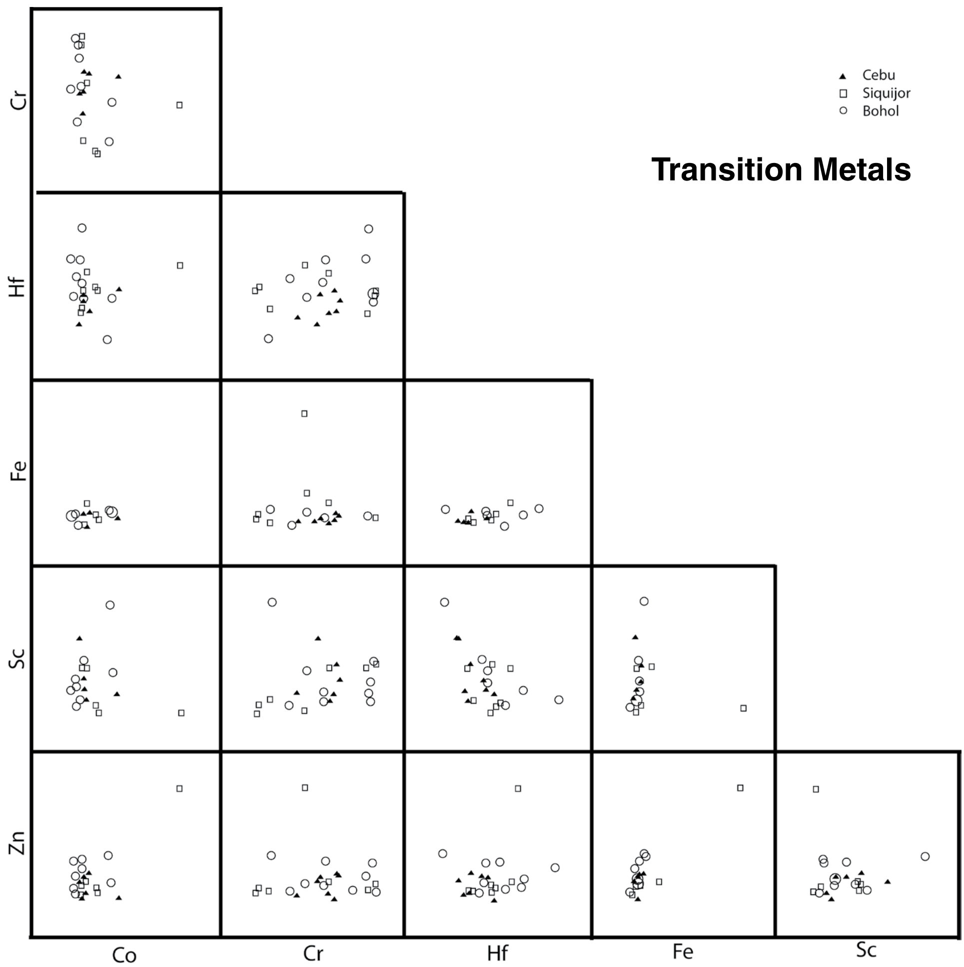

Fig. 5 (*Continued*)

DISCUSSION

The four samples from Group A (AY02, AY07, AY08, AY16) were all globular shaped pots associated with site C-11 on Bohol. Based on elemental concentrations alone, links between low concentrations of Na and high As with the area's geologic formation or stylistic differences cannot be directly established. We would expect, based on the abundance of feldspar materials in the region, that local materials would be enriched in alkali metals such as Na or K. However, this expectation did not apply to Group A although other samples from the same site did yield higher concentrations of both elements (AY04 was extremely high in K and Rb). In fact, other potsherds from site C-11 fell into Group B and C for Na, suggesting the heterogeneous nature of clay materials in this region and lending support to an observation Bacus had earlier proposed (1995 : 222). Examination of Group A potsherds under a low-powered (30×) microscope showed the grains to be much smaller and more well rounded than other potsherds in the site sample.

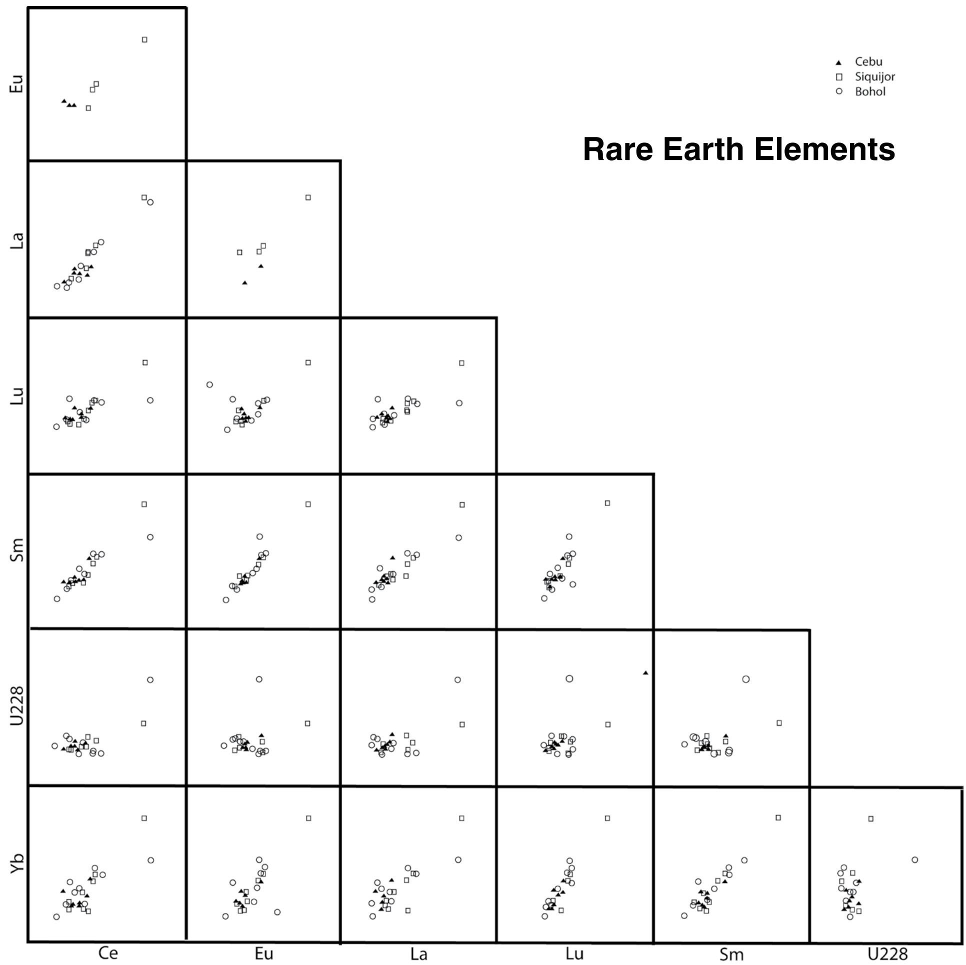

Fig. 5 (*Continued*)

The absence of separation on transition metals was another unanticipated finding given the limited distribution of andesitic materials on both Cebu and Bohol (Figure 5). Samples from sites downstream of dioritic regions did not yield the expected elemental concentrations (Sc) of characteristic transition minerals. This may be due to the predominance of plagioclase and low concentration of amphiboles and olivines in the dioritic material. However, in the absence of greater sample size and information on the geological formation of drainage systems, these groupings represent preliminary observations on paste variability.

One observation deserving further discussion is the outlier (AY01), which is also a globular vessel from the C11 site. AY01 was excluded from the final clustering solution for Group A because of extremely high concentrations in rare earth elements (REE). Significant REE concentrations are unusual for this sample because sources of granite and basalt materials tend to be uncommon on the three islands. This expectation applied in most cases with the exception of AY01 (globular vessel) from C-11 and AY19 (rim of restricted vessel) from B-23 on Siquijor. In the absence of more precise

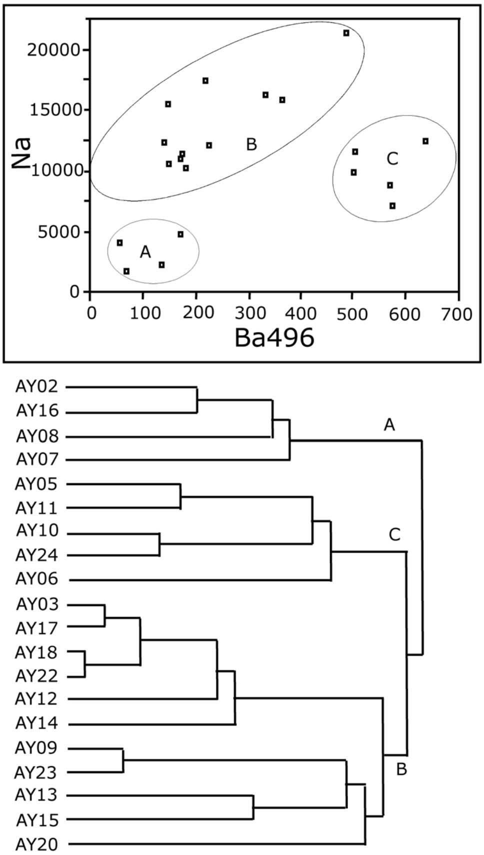

Fig. 6. Bivariate plot and cluster dendrogram for Na and Ba496.

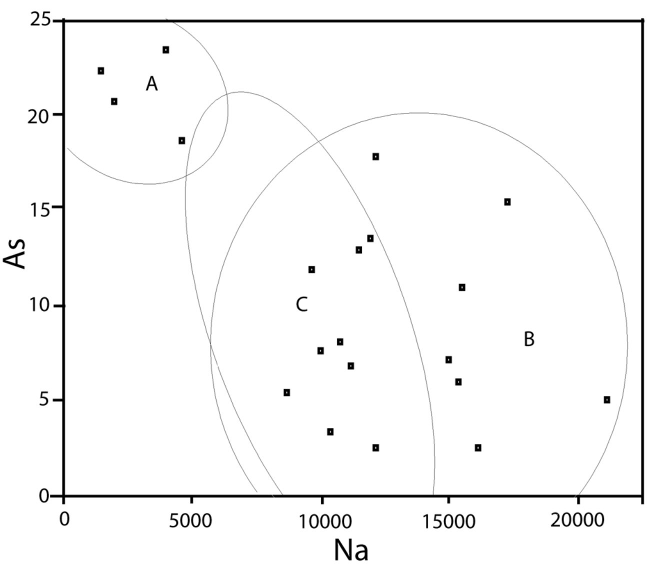

Fig. 7. Bivariate plot for Na and As with 95 percent confidence interval.

information on geological distributions in the central Visayan, it is difficult to specify the mineralogical sources for these REE enriched clays. AY01 was also one of two globular vessels with surface decoration, the exterior body being covered with a paddled cord design (see Figure 2*b*). Examination of AY01 and AY19 under a microscope at 30× showed poorly sorted grains that were highly angular. In addition, the paste was distinguished by inclusions of quartz and other dark materials. This observation, in contrast to the rounded grains of Group A potsherds containing few aplastic inclusions, suggests a tentative distinction between well-worked beach sand material perhaps of the coastal areas and angular grains that may be particular to interior regions of mafic materials.

Another outlier, AY21 (see Figure 3*b*), from C-74 on Siquijor also provides interesting results that suggest the presence of mafic materials in a region where no substantial dioritic formations are documented. AY21 is saturated with concentrations of Fe, possibly indicative of a source of pyroxene minerals, silicates containing substantial amounts of Fe.

The inconclusive nature of the compositional analysis is likely attributed to problems with the small sample size. Specifically, the number of samples taken from each site was insufficient to represent the variability in the assemblage. Suggestions for future investigations should focus on taking larger samples from sites located within the same drainage system (Niziolek 2013) and also include a more comprehensive assessment of aplastic inclusions in the potsherds to determine other factors affecting elemental concentrations. Better chronological identification of the earthenware samples could also improve control over the sources of variability. However, since this study represents a pilot exploration of these archaeological materials using the INAA method, prior knowledge about compositional variability in earthenware was limited and an attempt was made to sample from a variety of contemporary sites to provide wider regional coverage.

CONCLUSION

The INAA results did not indicate significant group separations in elemental composition. Preliminary results showed that the most consistent grouping was characterized by low Na and Ba496, an unexpected association given the prevalence of feldspar materials in the geologic formation of the region. The outlier observations containing higher concentrations of elements associated with mafic materials also merit further consideration, but without greater knowledge of local geologic processes and drainage systems, it is difficult to identify the geographic origin of these materials.

The elemental information derived from this study represents an exploratory effort. The preliminary chemical profiles derived from the INAA analysis, with future involvement in the creation of a database, can be productive to investigations into these local trade networks.

ACKNOWLEDGMENTS

I would like to thank Leah Minc for providing me with training in INAA. Her patience in this learning process is much appreciated. Also, I thank Dr. Carla Sinopoli for access to the Guthe materials in the Museum of Anthropology. Any faults with this study are the responsibility of the author.

Appendix 1. Elemental Concentrations for Individual Samples (ppb).

ID	batch	ba496	K	Na	Cs	Rb	Cr	Co	Hf	Fe	Sc	Zn
AY01	R935-01-1Q	396.9591	15422.83	3300.721	9.802319	98.48916	71.96918	10.61917	4.920473	32281.08	15.76282	77.04993
AY02	R935-01-1Q	69.92017	5290.89	1515.914	1.164899	16.80455	125.7241	6.95234	5.937097	55511.51	20.01614	89.3725
AY03	R935-01-1Q	150.0576	7053.261	10423.52	1.187818	16.66048	202.9099	8.949648	3.978111	58295.91	23.15639	188.3946
AY04	R935-01-1Q	433.9619	35501.61	15027.51	2.204863	105.9917	97.39436	32.2331	3.875708	65719.31	26.26077	95.57103
AY05	R935-01-1Q	502.3257	15269.57	9682.741	3.853756	55.94884	173.4151	11.38516	3.583546	47051.43	19.02216	66.39859
AY10	R935-01-1Q	576.1685	15134.62	6996.208	2.465264	38.85133	142.8025	35.79999	4.333813	53885.54	18.68633	38.80684
AY11	R935-01-1Q	505.9995	19089.04	11457.81	2.40477	34.20284	133.2278	15.66462	3.018293	41056.25	17.04412	60.75944
AY12	R935-01-1Q	137.9664	9080.599	12171.43	0.8436335	12.04319	118.9119	14.20292	3.978386	51830.97	19.9902	122.5699
AY13	R935-01-1Q	218.9697	8437.709	17198.97	1.33739	31.81133	150.0627	14.43149	3.732656	59631.82	23.0771	127.6952
AY14	R935-01-1Q	224.6711	6105.204	11964.73	0.8314109	27.2974	145.821	17.48032	3.120155	64811.13	27.99443	137.8824
AY06	R935-01-1Q	641.259	12696.61	12203.7	0.5614988	17.00855	38.48561	30.18993	1.679286	75971.51	47.33761	208.6205
AY07	R935-01-1Q	174.4159	10677.11	4683.064	0.9522957	18.19669	127.239	13.37621	4.679112	49447.57	16.54057	188.7152
AY08	R935-01-1Q	56.89942	4937.589	3978.408	1.8479	28.42789	195.0407	11.18949	5.932432	58818.87	19.94484	114.0755
AY09	R935-01-1Q	365.8575	14986.43	15541.02	1.241909	41.65895	82.35315	13.47314	2.780684	41684.76	19.1219	55.36602
AY15	R935-01-1Q	148.2345	12898.69	15353.23	0.2543213	28.3818	114.7305	11.89953	2.406293	44356.14	36.12989	105.5878
AY16	R935-01-1Q	136.1921	4153.984	2064.821	1.153901	−14.29175	199.1937	13.30938	7.64781	52463.75	17.00508	167.0191
AY17	R935-01-1Q	181.5929	−7139.308	9982.411	1.38056	−15.88621	209.7165	13.88211	4.243376	55886.77	27.9261	96.87843
AY18	R935-01-1Q	172.4591	6262.377	11243.48	1.462945	12.22901	194.8421	13.74057	2.984866	51065.12	26.94545	76.92753
AY19	R935-01-1Q	106.8105	−7281.636	2486.047	0.8657089	−17.82976	134.7068	17.16053	5.22295	93882.77	27.22663	106.0287
AY20	R935-01-1Q	487.8205	10362.66	21151.04	2.634697	24.08164	17.33991	23.55375	4.281824	46874.82	13.30709	65.712
AY21	R935-01-1Q	147.3557	14750.34	1990.2	−0.4722241	−28.08586	96.54304	73.68871	5.639895	331976.2	13.87209	464.9571
AY22	R935-01-1Q	170.8984	−10903.54	10809.96	1.109508	−16.13674	207.5924	14.56445	3.705229	54988.19	29.61121	71.50185
AY23	R935-01-1Q	334.7743	8036.26	16086.91	1.928082	13.07198	21.57161	22.09143	4.508643	63529.77	15.50788	84.89372
AY24	R935-01-1Q	570.6032	14927.11	8723.958	1.62265	25.36368	38.53063	14.47542	3.263715	40593.4	17.27539	68.29664

(*Continued*)

Appendix 1 (*Continued*)

ID	BATCH	As	Sb	Th	Sm	U228	Yb	Ce	Eu	Ta	Tb	La	Lu
AY01	R935-01-1Q	3.361013	1.256517	15.42598	6.715888	6.121128	3.13036	72.28036	1.396484	1.160555	0.8332624	35.02988	0.3595788
AY02	R935-01-1Q	22.15552	1.213023	4.096219	1.621505	1.301805	1.09818	12.54565	0.4570487	0.298832	0.2331904	7.57701	0.1730999
AY03	R935-01-1Q	3.194256	0.5860098	2.758146	2.756763	1.727584	2.327572	20.64395	0.6563553	0.2887368	0.5038682	9.241864	0.377821
AY04	R935-01-1Q	7.016498	0.2730342	2.310532	3.698539	1.060943	1.602904	30.53119	1.181965	0.1683289	0.3191512	13.65444	0.2205438
AY05	R935-01-1Q	11.59017	0.573453	2.438054	2.459833	1.886467	1.540924	18.9605	0.7688012	0.2990821	0.2363449	7.421396	0.2304306
AY10	R935-01-1Q	15.2765	0.6088606	2.406731	3.508512	1.380654	1.80949	32.01915	0.9844733	0.2840959	0.4352395	11.13778	0.2720133
AY11	R935-01-1Q	12.69824	0.5115473	2.063308	2.926204	1.121855	1.507445	23.30993	0.8717585	0.2753872	0.4432966	11.89483	0.22475
AY12	R935-01-1Q	17.56363	0.7845085	2.586831	3.540845	1.204926	1.654177	28.1589	1.077416	0.5402555	0.5072274	12.14823	0.2452423
AY13	R935-01-1Q	15.28523	0.5316918	2.554856	3.1142	1.147452	1.448385	21.67747	0.9400874	0.4091146	0.3808086	10.79167	0.2314702
AY14	R935-01-1Q	13.41051	1.063403	2.1471	4.991242	1.948965	2.389435	34.07138	1.430861	0.5258973	0.5999987	13.76466	0.3136426
AY06	R935-01-1Q	2.260963	−0.2444313	1.019073	4.119275	0.6626089	2.10924	26.80025	1.352994	−0.1343539	0.5853707	10.28995	0.2714981
AY07	R935-01-1Q	18.52041	0.9219574	3.743836	5.291302	0.7260887	2.650761	41.08059	1.451021	0.271621	0.6165715	21.8915	0.3483829
AY08	R935-01-1Q	23.19135	0.9542152	4.192338	3.392242	1.567468	1.957385	23.93972	0.8889585	0.3904647	0.5068878	13.13197	0.3046704
AY09	R935-01-1Q	10.77021	0.5913175	2.026734	3.189503	0.9600803	1.444391	26.29386	0.9178925	0.2869631	0.1297303	11.63358	0.1898914
AY15	R935-01-1Q	5.869589	0.3999359	0.9613296	3.004888	0.9394153	1.998985	17.25179	1.010692	0.1608293	0.3878555	8.702838	0.2388664
AY16	R935-01-1Q	20.5348	1.397616	3.571177	5.323024	0.9045467	2.838304	36.37508	1.583721	0.3594818	0.993382	18.82989	0.3772556
AY17	R935-01-1Q	7.381783	0.6548484	3.690231	5.048962	1.528153	2.63014	37.5801	1.510479	0.3082164	0.6275786	20.67531	0.364915
AY18	R935-01-1Q	6.55541	0.627	3.231214	3.258967	1.463186	1.951732	28.58221	1.014382	0.3119683	0.5575247	14.1591	0.2571323
AY19	R935-01-1Q	13.12877	0.9239618	5.844634	9.49227	2.838552	4.683105	69.1224	2.746235	0.5234605	1.358006	36.43293	0.6432976
AY20	R935-01-1Q	4.859576	0.6092271	3.08455	2.973885	1.451959	1.355758	30.40471	0.9740036	0.2498146	0.4663268	12.67214	0.221114
AY21	R935-01-1Q	5.273169	1.502826	2.442501	3.524856	1.935822	1.293108	32.59259	0.8477994	0.4210238	−0.3397811	18.48522	0.2977204
AY22	R935-01-1Q	7.94257	0.6153609	3.438712	4.49244	0.6990731	2.367797	35.75264	1.372499	0.296748	0.6250473	18.70188	0.3521115
AY23	R935-01-1Q	2.35391	0.3986286	3.064777	2.951712	0.9086708	1.348241	20.4935	0.9077728	0.2966033	0.3099017	10.45622	0.2009048
AY24	R935-01-1Q	5.234302	0.4701197	1.861225	2.6901	0.963252	1.606613	20.18191	0.7412992	0.2167532	0.3192732	10.35979	0.2092655

NOTE

1. Sites B23 and C74 on the island of Siquijor were included in order to achieve wider spatial coverage. Their relative contemporaneity with Bohol and Cebu sites is suggested by the presence of iron implements.

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ABSTRACT

This study undertakes an elemental compositional analysis of Philippine earthenware vessels from the Guthe collection using Instrumental Neutron Activation Analysis (INAA). Unlike foreign trade ceramics, earthenware vessels were locally produced goods but which also played a part in the development of Philippine chiefdoms as an item traded between inland and coastal groups. Thus, the detection of compositional groups within earthenware vessels may help identify patterns of production and exchange. It is also hoped that the results from this pilot study can contribute to the future development of an elemental database for earthenware vessels. Keywords: Philippines, earthenware, exchange, Instrumental Neutron Activation Analysis.